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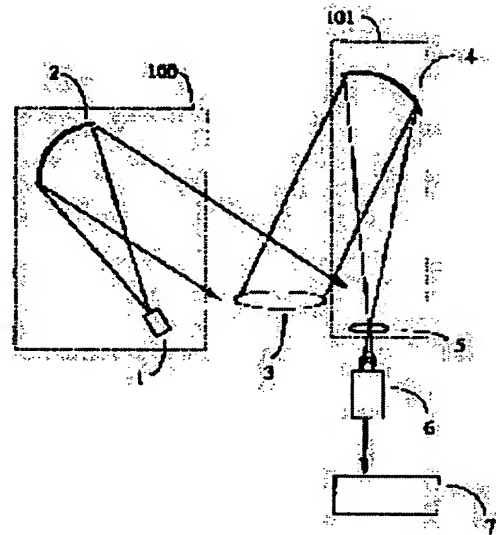
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(54) AUTOMATIC MACROSCOPIC INSPECTION APPARATUS

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain an automatic macroscopic inspection apparatus by which the macroscopic inspection of various objects to be inspected can be performed with good efficiency while an illumination device, an imaging device and the like are kept fixed.

SOLUTION: An automatic macroscopic inspection apparatus is constituted of an illumination optical system 100 which is fixed, arranged and installed at a first prescribed angle with reference to a wafer 3 and by which illumination light comprising nearly parallel luminous fluxes is irradiated toward the whole face of the wafer 3, of an imaging element 6 which is fixed, arranged and installed at a second prescribed angle with reference to the wafer 3, which receives diffracted light or scattered light from the wafer 3 and which images the image of the wafer 3 and of an image processor 7 which fetches an image signal obtained by the imaging element 6 so as to perform an image processing operation and which performs a macroscopic inspection. It is provided with a plurality of interference filters by which the wavelength of the illumination light from the illumination optical system 100 is set so as to be variable.



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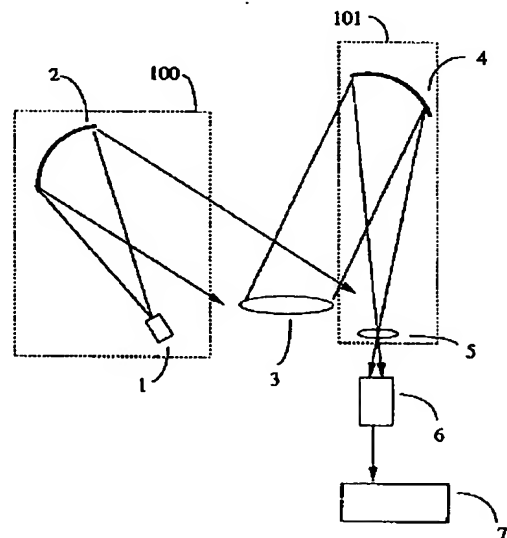
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(54)【発明の名称】 自動マクロ検査装置

(57)【要約】

【課題】 照明装置、撮像装置等を固定したまま、さまざまな被検査物のマクロ検査を効率よく行うことができるようにする。

【解決手段】 ウエハ3に対して第1の所定角度で固定配設され、ウエハ3の全面に向かってほぼ平行な光束を有した照明光を照射する照明光学系100と、ウエハ3に対して第2の所定角度で固定配設され、ウエハ3から回折光もしくは散乱光を受光してウエハの像を撮像する撮像素子6と、この撮像素子6により得られた画像信号を取り込み、画像処理を行ってマクロ検査を行う画像処理装置7とから構成され、照明光学系100からの照明光の波長を可変設定する複数の干渉フィルターを備えている。



【特許請求の範囲】

【請求項 1】 被検査物に対して第 1 の所定角度で対向して固定配設され、前記被検査物の全面に向かってほぼ平行な光束を有した照明光を照射する照明装置と、前記被検査物に対して第 2 の所定角度で対向して固定配設され、前記被検査物から前記照明光の照射により発生する回折光もしくは散乱光を受光して前記被検査物の像を撮像する撮像手段と、この撮像手段により得られた画像信号を取り込み、画像処理を行って前記被検査物のマクロ検査を行う画像処理手段と、前記照明装置からの照明光の波長を可変設定する照明波長設定手段とを備えたことを特徴とする自動マクロ検査装置。

【請求項 2】 前記照明装置が、拡散光源と、この拡散光源からの光をほぼ平行な光束に変換する平行変換手段とからなることを特徴とする請求項 1 に記載の自動マクロ検査装置。

【請求項 3】 前記平行変換手段が、前記拡散光源が焦点位置になるようにして配設された凹面鏡からなることを特徴とする請求項 2 に記載の自動マクロ検査装置。

【請求項 4】 前記撮像手段が、前記被検査物からの前記回折光もしくは散乱光を収束させる凹面鏡と、この凹面鏡により収束された前記回折光もしくは散乱光から前記被検査物の像を結像させて撮像するカメラ手段とからなることを特徴とする請求項 1～3 のいずれかに記載の自動マクロ検査装置。

【請求項 5】 前記照明装置が、ライン状の拡散光源と、このライン状拡散光源のラインに沿って対向配設されたシリンドリカルレンズとからなり、このシリンドリカルレンズにより前記ライン状拡散光源からの光を少なくとも一方向にほぼ平行となる光束を作り出して前記被検査物を照明することを特徴とする請求項 1 に記載の自動マクロ検査装置。

【請求項 6】 前記第 1 の所定角度が前記被検査物の表面に直角な線に対して角度 θ_i であり、前記第 2 の所定角度が前記被検査物の表面に直角な線に対して角度 θ_d であるときに、前記照明波長設定手段により設定される前記照明光の波長 λ が、次式

$$(\sin \theta_i - \sin \theta_d) = n \cdot \lambda / p$$

但し、 n ： 撮像対象となる回折光の次数

p ： 被検査物の表面のパターンピッチ

を満足するように設定されることを特徴とする請求項 1 に記載の自動マクロ検査装置。

【請求項 7】 前記第 1 の所定角度が前記被検査物の表面に直角な線に対して角度 θ_i であり、前記第 2 の所定角度が前記被検査物の表面に直角な線に対して角度 θ_d であり、前記照明波長設定手段により設定される前記照明光の波長を λ としたときに、次式

$$(\sin \theta_i - \sin \theta_d') = n \cdot \lambda / p$$

但し、 n ： 照明光から発生する回折光の次数

p ： 被検査物の表面のパターンピッチ

により決まる角度 θ_d' と、

$$(\sin \theta_i - \sin \theta_d'') = (n+1) \cdot \lambda / p$$

により決まる角度 θ_d'' とに対して、

$$\theta_d' < \theta_d < \theta_d''$$

となるような前記照明光の波長 λ が前記照明波長設定手段により設定されることを特徴とする請求項 1 に記載の自動マクロ検査装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、液晶製造用ガラス基板や、IC製造用のウエハ等の表面検査を行う装置に関し、特に、いわゆるマクロ検査と称される被検査物の表面全体の検査を行う装置に関する。

【0002】

【従来の技術】液晶製造用ガラス基板や、IC製造用のウエハ等（以下、これらを被検査物とも称する）の表面のマクロ検査は、基板、ウエハ等の表面のキズ、レジスト塗布むら、フォトリソグラフィ工程における欠陥などを、被検査物の表面全体を観察して検査を行うものである。従来のマクロ検査は、スポットライト状の白色拡散光源を用いて、被検査物を回転させながら検査員が目視判断して検査していた。

【0003】しかしながら、検査員による目視検査では、検査員毎の技術レベル差、および検査員の体調等による検査レベルのばらつきがあり、安定した検査結果が得にくい、効率が良くない等という問題がある。また、液晶製造用ガラス基板、IC製造用のウエハ等の製造に際しては微細な異物の付着等による表面汚染を避けなければならないので、発塵要因となる人間による検査工程はできるかぎり避けるべきである。

【0004】このようなことから、マクロ検査工程を自動化することが提案されており、このようなものとして、特公平 6-8789 号公報に開示の装置がある。この装置では、ウエハ表面に光を照射し、この表面からの反射光を ITV カメラで受光して、被検査物の表面全体の反射光画像を取得し、このようにして得られた反射光画像を予め測定した正常検査物の反射光画像と比較する画像処理を行って被検査物のマクロ検査を行うようになっている。この装置においては、ウエハ表面に対する光の照射角度を種々変更して検査できるように、ITV カメラは固定したままで、ウエハ表面角度および照明角度を可変設定できるようになっている。

【0005】

【発明が解決しようとする課題】しかしながら、このような自動マクロ検査装置の場合には、ウエハ表面角度および照明角度を可変設定させる機構が必要であり、このような機構の作動に際して可動部分からの発塵が生じて被検査物表面を汚染する可能性があるという問題があ

る。なお、上記公報に開示の装置は、被検査物の表面から直接反射される光を用いてマクロ検査を行うようになっており、被検査物表面への照射光の入射角度と反射光の反射角度が等しくなる位置にカメラが配設される。

【0006】しかし、最近においては、被検査物の表面の繰り返しパターンに応じて発生する回折光や、散乱光等を検査対象とすることが考えられている。このような場合には、検査対象となる反射光の反射角度は、被検査物のパターンピッチ等に応じて変化するため、これら各種の角度に対応できるように、照明装置の照明角度、撮像カメラの受光角度を調整する必要がある。このため、この場合にも角度調整機構が必要であり、この機構からの発塵による被検査物表面の汚染等が問題となる。

【0007】本発明はこのような問題に鑑みたもので、照明角度、被検査物の表面角度、受光装置もしくは撮像装置の受光角度等を可変調整することなく、すなわち、照明装置、撮像装置等を固定したまま、さまざまな被検査物のマクロ検査を効率よく行うことができるような自動マクロ検査装置を提供することを目的とする。

【0008】

【課題を解決するための手段】このような目的達成のため、本発明に係る自動マクロ検査装置は、被検査物に対して第1の所定角度で固定配設され、被検査物の全面に向かってほぼ平行な光束を有した照明光を照射する照明装置と、被検査物に対して第2の所定角度で固定配設され、被検査物から回折光もしくは散乱光を受光して被検査物の像を撮像する撮像手段と、この撮像手段により得られた画像信号を取り込み、画像処理を行って被検査物のマクロ検査を行う画像処理手段と、照明装置からの照明光の波長を可変設定する照明波長設定手段とを備えて構成される。

【0009】このような構成の自動マクロ検査装置の場合には、照明波長設定手段により照明光の波長を可変設

$$(\sin \theta_i - \sin \theta_d) = n \cdot \lambda / p \quad \cdots (1)$$

但し、 n ：撮像対象となる回折光の次数

p ：被検査物の表面のパターンピッチ

【0014】このように照明光の波長 λ を設定すれば、撮像手段により効率良く n 次の回折光を捉えて、この回折光を用いたマクロ検査を効率良く行うことができる。

【0015】なお、回折光ではなく散乱光を撮像手段により捉えてマクロ検査を行うときには照明波長設定手段により波長設定は次のようにして行われる。すなわち、第1の所定角度が被検査物の表面に直角な線に対して角

$$(\sin \theta_i - \sin \theta_{d'}) = n \cdot \lambda / p \quad \cdots (2)$$

$$(\sin \theta_i - \sin \theta_{d''}) = (n+1) \cdot \lambda / p \quad \cdots (3)$$

但し、 n ：照明光から発生する回折光の次数

p ：被検査物の表面のパターンピッチ

【0017】このようにして照明光の波長 λ を設定すれば、 n 次の回折光の方向と $(n+1)$ 次の回折光の方向との間に撮像手段が位置し、撮像手段には回折光は入射

定できるので、被検査物から射出される回折光および散乱光の方向を結像撮影手段の受光方向に合致するように波長を設定すれば、効率の良いマクロ検査が行える。このため、このマクロ検査装置の場合には、照明装置および結像撮影手段を固定することができ、従来の装置のようにこれらの向きを変える可動機構が不要であるので、余計な発塵源がなくなり、被検査物の汚染が抑えられる。

【0010】なお、照明装置を、拡散光源およびこれらの光をほぼ平行な光束に変換する平行変換手段から構成するのが好ましく、この場合、平行変換手段を、拡散光源が焦点位置になるようにして配設された凹面鏡から構成するのが好ましい。このように凹面鏡を用いることにより白色光を用いた照明の場合でも色収差発生の問題がなくなる。また、同様な理由から、撮像手段を、被検査物からの回折光もしくは散乱光を収束させる凹面鏡と、この凹面鏡により収束された光から被検査物の像を撮影するカメラ手段とから構成するのが好ましい。

【0011】また、照明装置を、ライン状の拡散光源と、このライン状拡散光源のラインに沿って対向配設されたシリンドリカルレンズとから構成することもでき、この場合には、シリンドリカルレンズによりライン状拡散光源からの光を少なくとも一方向にほぼ平行となる光束を作り出して被検査物を照明する。

【0012】ここで、照明波長設定手段による波長設定は、次のようにして行われる。すなわち、上記第1の所定角度が被検査物の表面に直角な線に対して角度 θ_i であり、上記第2の所定角度が前記被検査物の表面に直角な線に対して角度 θ_d であるときに、照明光の波長 λ が、次式(1)を満足するように設定される。

【0013】

【数1】

度 θ_i であり、第2の所定角度が被検査物の表面に直角な線に対して角度 θ_d であり、照明波長設定手段により設定される照明光の波長を λ としたときに、次式(2)により決まる角度 $\theta_{d'}$ と、次式(3)により決まる角度 $\theta_{d''}$ とに対して、 $\theta_{d'} < \theta_d < \theta_{d''}$ となるような照明光の波長 λ が照明波長設定手段により設定される。

【0016】

【数2】

せず、散乱光のみが入手する。このため、この場合には、散乱光を用いたマクロ検査を効率良く行うことができる。

【0018】

【発明の実施の形態】以下、本発明の好ましい実施形態

について説明する。図1に本発明に係る自動マクロ検査装置の第1の実施例に係る概略構成を示しており、この装置は、ウエハ（被検査物）3の表面に平行光束の照明光を照射する照明光学系100と、ウエハ3からの回折光、散乱光等を受光する受光系101と、撮像素子（撮像カメラ）6と、画像処理装置7とから構成される。

【0019】照明光学系100は、光源部1と凹面鏡2によって構成される。光源部1は凹面鏡2の焦点位置に配設されており、光源部1からの拡散光は凹面鏡2により平行光束に変換されてウエハ3に向かって照射される。このとき凹面鏡2はウエハ3の全面を照明可能な口径を有し、平行光束の照明光によりウエハ3の全面が同時に照明される。光源部1は白色光源であるハロゲンランプと、照明波長域を制限する干渉フィルタとを有する。この干渉フィルタは所定の波長域の光を透過するバンドパスフィルタとして機能し、異なる波長域の光を透過させる複数の干渉フィルタを外から手動ないし遠隔操作により切り替え、光源部1から照射される光の波長選択が可能となっている。

【0020】受光系101は、上記のようにしてウエハ3に照射されたときにウエハ3から発生する回折光もしくは散乱光を受光するもので、ウエハ3の全面からの回折光もしくは散乱光を取り込むに十分な口径を有した凹面鏡4と、この凹面鏡4に入射して集光された光を結像させる受光レンズ5とを有する。このとき受光レンズ5は撮像素子6に結像させるようになっており、撮像素子6によりウエハ3の回折光もしくは散乱光の像が撮影される。

$$(\sin \theta_i - \sin \theta_d) = n \cdot \lambda / p \quad \cdots (4)$$

但し、 λ ： 照明光の波長

n ： 撮像対象となる回折光の次数

【0026】このため、ウエハ3に対して、入射角度が角度 θ_i となる方向から平行光束照明が行われるように照明光学系100を配設し、回折光の反射角度 θ_d に対向して凹面鏡4が位置するように受光系101を配設すると、照明光の波長が λ のときに、受光系101により n 次の回折光を最も効率よく受光できることがわかる。本例では、照明光学系100および受光系101を固定配設しており、その配設位置に対して、 n 次の回折光が最も効率よく受光系101により受光されるような波長 λ となるように干渉フィルタが選択される。

【0027】一方、受光系101により散乱光を受光し

$$(\sin \theta_i - \sin \theta_{d'}) = n \cdot \lambda / p \quad \cdots (5)$$

$$(\sin \theta_i - \sin \theta_{d''}) = (n+1) \cdot \lambda / p \quad \cdots (6)$$

【0029】上記のように波長 λ の選択を行うと、この波長の照明光がウエハ3に照射されたときに、図4に示すように、 n 次の回折光は角度 $\theta_{d'}$ の方向に射出され、 $(n+1)$ 次の回折光は $\theta_{d''}$ の方向に射出され、これらの間に受光系101の凹面鏡4が位置するため、受光系101には回折光は入射せず、散乱光のみが受光

【0021】このようにして撮像素子6により撮影されたウエハの像は、画像処理装置7に送られ、ここに予め撮影されて記憶されている正常ウエハの像と比較して、表面欠陥検査等のマクロ検査が行われる。

【0022】この例においては、光源部1は凹面鏡の前側焦点位置付近に配設され、ウエハ3は凹面鏡4の後側焦点面付近に配設されており、これにより、凹面反射鏡を用いた反射型のテレセントリック光学系としている。このように光学系に凹面鏡を用いているために色収差の問題がなく、精度の高い検査が可能である。

【0023】このような構成の自動マクロ検査装置を用いてウエハ3のマクロ検査を行う例を説明する。まず、図示しない搬送機構により図2に示す検査位置にウエハ3が搬送される。そして、上記のような配置に対応するとともに検査の種類に対応して光源部1の干渉フィルタを選択する。この例では、照明光学系100および受光系101は固定配設されており、照明光学系100からウエハ3への照明光の入射角度は常に一定であり、且つ受光系101へ入射される回折光の回折角度も常に一定であるため、所望の検査光が受光系101に入射するように干渉フィルタの選択を行うものである。

【0024】この点について図3および図4を参照して詳しく説明する。図3に示すように、ウエハ3の表面に基本ピッチ p で繰り返しパターンが設けられている場合には、照明光の入射角度 θ_i と、回折光の射出角度 θ_d との関係は、次式（4）のようになる。

【0025】

【数3】

てマクロ検査を行う場合もある。この場合には、図4に示すように、 n 次の回折光の射出角度 $\theta_{d'}$ と、 $(n+1)$ 次の回折光の射出角度 $\theta_{d''}$ との間の位置に、受光系101の凹面鏡4が位置するように、照明光の波長 λ が設定される。具体的には、 n 次の回折光の射出角度 $\theta_{d'}$ は次式（5）で決まり、 $(n+1)$ 次の回折光の射出角度 $\theta_{d''}$ は次式（6）で決まるため、受光系101の凹面鏡4に入射する回折光の角度 θ_d が、 $\theta_{d'} < \theta_d < \theta_{d''}$ となるような照明光の波長 λ が照明波長設定手段により設定される。

【0028】

【数4】

され、散乱光を用いた効率の良いマクロ検査が行われる。

【0030】ここで元に戻って、上記のようにして受光系101により受光された回折光もしくは散乱光は、凹面鏡4により受光レンズ5に集光されるとともに受光レンズ4により撮像素子6の上に結像される。このように

して撮像素子 6 により撮影された画像情報は、画像処理装置 6 に送られ、正常ウエハの画像と対比されてマクロ検査が自動的に行われる。

【0031】なお、ウエハ 3 を検査位置で支持する装置に回転支持機構を設け、ウエハ 3 の回転位置調整を行えるようにしても良い。このようにした場合、ウエハ 3 のパターン方向、キズ欠陥等のように、照明光と、回折光強度、散乱光の発生方向が回転位置に応じて異なるときに、ウエハ 3 を回転させて最も検査効率の良い方向に設定することができる。

【0032】なお、上記実施例では、凹面鏡を用いたが、これに変えて反射型のフレネルゾーンプレートを用いても良い。さらに、レンズを用いた屈折光学系で色収差補正を行ったものを用いることもできる。

【0033】次に、本発明に係る自動マクロ検査装置の第 2 の実施例について図 2 を参照して説明する。なお、この例の装置において、上記第 1 の実施例の装置と同一部分には同一の符号を付して説明する。この装置は、照明光学系 102、受光系 101、撮像素子 6 および画像処理装置 7 から構成され、照明光学系 102 のみが第 1

の実施例の装置と異なるだけである。

【0034】照明光学系 102 は、光源部 10 と、光ファイバ送光系 11 およびシンドリカルレンズ 12 によって構成され、ウエハ 3 の全面を照明可能な光束をウエハ 3 に照射する。光源部 10 は白色光源光であるハロゲンランプと、照明波長域を制限する干渉フィルタとからなる。これについては、第 1 の実施例と同一構成である。

【0035】光ファイバ送光系 11 は、一端側（入射端）が光源部 10 に対向して光源部 10 からの照明光を受光し、他端側（出射端）は一次元のライン状に配列されて構成されている。このため、光ファイバ送光系 11 の他端側からの射出光束は、図 2 の紙面と平行な面内では角度 θ の広がり角度を持つ拡散光であり、紙面に垂直な方向へのファイバのライン長分の奥行きを持つ光源となる。

【0036】この光ファイバ送光系 11 の他端は、シンドリカルレンズ 12 の後側焦点となる位置に位置しており、光ファイバ送光系 11 の他端側から射出された拡散光はシンドリカルレンズ 12 により紙面に平行な面内では平行光束に近い光束に変換される。これにより、少なくとも図 2 の紙面に平行な面内では上記第 1 実施例で示したテレセントリック光学系と同等な平行光束がウエハ 3 の全面に照射される。

【0037】このようにウエハ 3 に照明光が照射されると、これにより生じる回折光もしくは散乱光が受光系 101 により受光され、撮像素子 6 により撮像され、画像処理装置 7 において画像処理がなされてマクロ検査が行われるのであるが、これについては第 1 実施例と同じなのでその説明は省略する。

【0038】このような構成のマクロ検査装置の場合には、照明光学系の構成が小型、コンパクト化でき、且つ低コスト化できる。

【0039】なお、上記第 1 および第 2 実施例において、光源部を、白色光源と分光器を組み合わせて構成することも可能である。

【0040】

【発明の効果】以上説明したように、本発明によれば、第 1 の所定角度で固定配設された照明装置と、第 2 の所定角度で固定配設されて回折光もしくは散乱光による被検査物の像を撮像する撮像手段と、この撮像手段により得られた画像から被検査物のマクロ検査を行う画像処理手段とを有し、さらに、照明波長設定手段により照明光の波長を可変設定できるように構成されているので、被検査物から射出される回折光および散乱光の方向を結像撮影手段の受光方向に合致するように波長を設定すれば、効率の良いマクロ検査が行える。このため、このマクロ検査装置の場合には、照明装置および結像撮影手段を固定することができ、従来の装置のようにこれらの向きを変える可動機構が不要であり、余計な発塵源がなくなり、被検査物の汚染を抑えることができる。

【0041】なお、照明装置を、拡散光源およびこれからの光をほぼ平行な光束に変換する平行変換手段から構成するのが好ましく、この場合、平行変換手段を、拡散光源が焦点位置になるようにして配設された凹面鏡から構成するのが好ましい。このように凹面鏡を用いることにより白色光を用いた照明の場合でも色収差発生の問題がなくなる。また、同様な理由から、撮像手段を、被検査物からの回折光もしくは散乱光を収束させる凹面鏡と、この凹面鏡により収束された光から被検査物の像を撮影するカメラ手段とから構成するのが好ましい。

【0042】また、照明装置を、ライン状の拡散光源と、このライン状拡散光源のラインに沿って対向配設されたシンドリカルレンズとから構成することもでき、この場合には、シンドリカルレンズによりライン状拡散光源からの光を少なくとも一方向にほぼ平行となる光束を作り出して被検査物を照明する。このようにすれば、照明装置を小型、コンパクト化して、低コスト化を図ることができる。

【0043】なお、回折光を用いたマクロ検査を行うときには、照明波長設定手段による波長設定は、前述の式（1）を満足するようになされる。この式（1）は回折光が受光系（撮像手段）の方に射出されるための条件であり、これにより、撮像手段により効率良く n 次の回折光を捉えて、この回折光を用いたマクロ検査を効率良く行うことができる。

【0044】回折光ではなく散乱光を撮像手段により捉えてマクロ検査を行うときには照明波長設定手段により波長設定は、前述の式（2）により決まる角度 $\theta d'$ と、前述の式（3）により決まる角度 $\theta d''$ とに対し

て、 $\theta d' < \theta d < \theta d''$ となるような照明光の波長 λ が照明波長設定手段により設定される。このようにして照明光の波長 λ を設定すれば、 n 次の回折光の方向と $(n+1)$ 次の回折光の方向との間に撮像手段が位置し、撮像手段には回折光は入射せず、散乱光のみが入射する。このため、この場合には、散乱光を用いたマクロ検査を効率良く行うことができる。

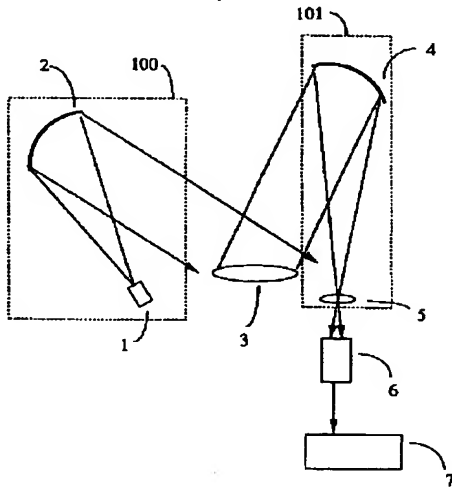
【図面の簡単な説明】

【図1】本発明の第1実施例に係る自動マクロ検査装置を示す概略図である。

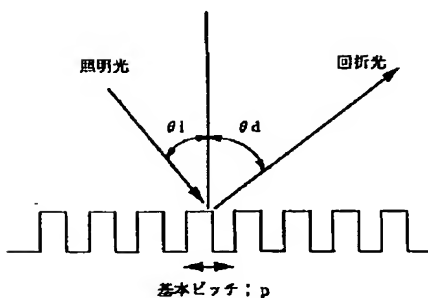
【図2】本発明の第2実施例に係る自動マクロ検査装置を示す概略図である。

【図3】ウエハに照射される照明光と回折光との関係を示す説明図である。

【図1】



【図3】

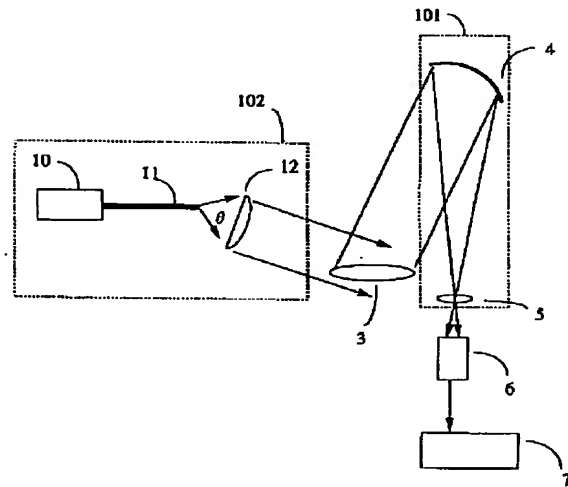


【図4】ウエハに照射される照明光と n 次および $(n+1)$ 次の回折光と受光系の凹面鏡位置との関係を示す説明図である。

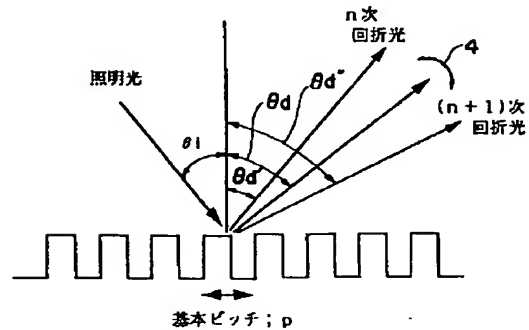
【符号の説明】

- 1, 10 光源部
- 2, 4 凹面鏡
- 3 ウエハ
- 5 受光レンズ
- 6 撮像素子
- 7 画像処理装置
- 10 光ファイバ送光系
- 11 シリンドリカルレンズ
- 100, 102 照明光学系
- 101 受光系

【図2】



【図4】



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CLAIMS

[Claim(s)]

[Claim 1] The lighting system which fixed arrangement is countered and carried out at the 1st predetermined include angle to an inspected object, and irradiates the illumination light with the almost parallel flux of light toward the whole surface of said inspected object, An image pick-up means for fixed arrangement to be countered and carried out at the 2nd predetermined include angle to said inspected object, to receive the diffracted light or the scattered light generated by the exposure of said illumination light from said inspected object, and to picturize the image of said inspected object, Automatic macro test equipment characterized by having an image-processing means to incorporate the picture signal acquired by this image pick-up means, to perform an image processing, and to conduct macro inspection of said inspected object, and the lighting wavelength setting means which carries out an adjustable setup of the wavelength of the illumination light from said lighting system.

[Claim 2] Automatic macro test equipment according to claim 1 characterized by said lighting system consisting of a source of the diffused light, and an parallel conversion means to change the light from this source of the diffused light into the almost parallel flux of light.

[Claim 3] Automatic macro test equipment according to claim 2 characterized by said parallel conversion means consisting of a concave mirror with which it was arranged in it as said source of the diffused light became a focal location.

[Claim 4] Automatic macro test equipment according to claim 1 to 3 characterized by said image pick-up means consisting of a camera means to make carry out image formation of the image of said inspected object, and to picturize it from said diffracted light which it converged with the concave mirror as which said diffracted light or scattered light from said inspected object is completed, and this concave mirror, or the scattered light.

[Claim 5] Automatic macro test equipment according to claim 1 characterized by making the flux of light from which said lighting system consists of Rhine-like a source of the diffused light, and a cylindrical lens by which opposite arrangement was carried out along Rhine of this source of the Rhine-like diffused light, and becomes almost parallel to an one direction at least about the light from said source of the Rhine-like diffused light by this cylindrical lens, and illuminating said inspected object.

[Claim 6] To a line with said 1st predetermined include angle right-angled on the front face of said inspected object, are include-angle θ_{tai} , and to a line with said 2nd predetermined include angle right-angled on the front face of said inspected object, when it is include-angle θ_{tad} the wavelength λ of said illumination light set up by said lighting wavelength setting means -- degree type ($\sin\theta_{tai} - \sin\theta_{tad}$) = $n \cdot \lambda / p$ -- however n: Degree p of the diffracted light used as the candidate for an image pick-up: Automatic macro test equipment according to claim 1 characterized by being set up so that the pattern pitch of the front face of an inspected object may be satisfied.

[Claim 7] Said 1st predetermined include angle is include-angle θ_{tai} to a line right-angled on the front face of said inspected object. When wavelength of said illumination light by which said 2nd predetermined include angle is include-angle θ_{tad} , and is set as the front face of said inspected object with said lighting wavelength setting means to a right-angled line is set to λ Degree type

$(\sin\theta_i - \sin\theta_d) = n\lambda/p$, however n : Degree p of the diffracted light generated from illumination light : Include-angle θ_d' decided by the pattern pitch of the front face of inspected object, $(\sin\theta_i - \sin\theta_d'') = \text{automatic macro test equipment according to claim 1 characterized by setting up the wavelength } \lambda \text{ of said illumination light which becomes } \theta_d' < \theta_d < \theta_d'' \text{ by said lighting wavelength setting means to include-angle } \theta_d'' \text{ decided by } -(n+1)\lambda/p$.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the equipment which inspects the whole front face of the inspected object especially called the so-called macro inspection about the equipment which conducts surface analyses, such as a glass substrate for liquid crystal manufacture, and a wafer for IC manufacture.

[0002]

[Description of the Prior Art] Macro inspection of front faces (these are also hereafter called an inspected object), such as a glass substrate for liquid crystal manufacture and a wafer for IC manufacture, inspects the defect in the crack of front faces, such as a substrate and a wafer, resist spreading unevenness, and a photolithography process etc. by observing the whole front face of an inspected object. Using the spotlight-like source of the white diffused light, rotating an inspected object, the inspector made a visual judgment and was inspecting the conventional macro inspection.

[0003] However, in the visual inspection by the inspector, there is a problem that there is dispersion in the inspection level by the skill level difference for every inspector, an inspector's condition, etc., and it is hard to obtain the stable inspection result, that it is not efficient, etc. Moreover, since it learns if surface contamination by adhesion of a detailed foreign matter etc. is not avoided on the occasion of manufacture of the glass substrate for liquid crystal manufacture, the wafer for IC manufacture, etc., the inspection process by human being leading to raising dust should be avoided [whether it can do and].

[0004] Since it is such, automating a macro inspection process is proposed and the equipment of an indication is in JP,6-8789,B as such a thing. With this equipment, light is irradiated on a wafer front face, the reflected light from this front face is received with an ITV camera, the image processing in comparison with the reflected light image of the normal inspection object which measured beforehand the reflected light image obtained by acquiring the reflected light image of the whole front face of an inspected object, and carrying out such is performed, and macro inspection of an inspected object is conducted. The ITV camera has come to be able to carry out an adjustable setup of a wafer surface include angle and the lighting include angle in this equipment, so that whenever [illuminating-angle / of the light to a wafer front face / various] can be changed and inspected, while it had been fixed.

[0005]

[Problem(s) to be Solved by the Invention] However, there is a problem that the device in which an adjustable setup of a wafer surface include angle and the lighting include angle is carried out is required in the case of such automatic macro test equipment, the raising dust from a part for moving part may arise on the occasion of actuation of such a device, and an inspected object front face may be polluted. In addition, a camera is arranged in the location where the equipment of an indication in the above-mentioned official report conducts macro inspection using the light directly reflected from the front face of an inspected object, and whenever [incident angle / of the exposure light to an inspected object front face], and whenever [angle-of-reflection / of the reflected light] become equal.

[0006] However, in recently, it considers making into a subject of examination the diffracted light

generated according to the repeat pattern of the front face of an inspected object, the scattered light, etc. In such a case, in order to change according to the pattern pitch of an inspected object etc., whenever [angle-of-reflection / of the reflected light used as a subject of examination] needs to adjust the lighting include angle of a lighting system, and the light-receiving include angle of an image pick-up camera so that it can respond to the include angle of these various kinds. For this reason, an include-angle adjustment device is required also in this case, and contamination of the inspected object front face by the raising dust from this device etc. poses a problem.

[0007] This invention is what took the example by such problem, and it aims at offering the automatic macro test equipment which can conduct macro inspection of various inspected objects efficiently, fixing a lighting system, image pick-up equipment, etc. without carrying out adjustable setting of the light-receiving include angle of a lighting include angle, the surface include angle of an inspected object, light-receiving equipment, or image pick-up equipment etc.

[0008]

[Means for Solving the Problem] The automatic macro test equipment concerning this invention for such purpose achievement The lighting system which fixed arrangement is carried out at the 1st predetermined include angle to an inspected object, and irradiates the illumination light with the almost parallel flux of light toward the whole surface of an inspected object, An image pick-up means for fixed arrangement to be carried out at the 2nd predetermined include angle to an inspected object, to receive the diffracted light or the scattered light from an inspected object, and to picturize the image of an inspected object, The picture signal acquired by this image pick-up means is incorporated, and it has an image-processing means to perform an image processing and to conduct macro inspection of an inspected object, and the lighting wavelength setting means which carries out an adjustable setup of the wavelength of the illumination light from a lighting system, and is constituted.

[0009] In the case of such automatic macro test equipment of a configuration, since an adjustable setup of the wavelength of the illumination light can be carried out with a lighting wavelength setting means, if wavelength is set up so that the direction of the diffracted light injected from an inspected object and the scattered light may be agreed in the light-receiving direction of an image formation photography means, efficient macro inspection can be conducted. For this reason, since the movable device in which can fix a lighting system and an image formation photography means in the case of this macro test equipment, and these sense is changed like conventional equipment is unnecessary, the excessive source of raising dust is lost and contamination of an inspected object is suppressed.

[0010] In addition, it is desirable to constitute a lighting system from an parallel conversion means to change the source of the diffused light and a future light into the almost parallel flux of light, and it is desirable to constitute an parallel conversion means from a concave mirror with which it was arranged in it as the source of the diffused light became a focal location in this case. Thus, also in the case of lighting using the white light, the problem of chromatic-aberration generating is lost by using a concave mirror. Moreover, since it is the same, it is desirable to constitute from a camera means to photo the image of an inspected object from the light which it converged in the image pick-up means with the concave mirror as which the diffracted light or the scattered light from an inspected object is completed, and this concave mirror.

[0011] Moreover, a lighting system can also be constituted from Rhine-like a source of the diffused light, and a cylindrical lens by which opposite arrangement was carried out along Rhine of this source of the Rhine-like diffused light, the flux of light which becomes almost parallel to an one direction at least about the light from the source of the Rhine-like diffused light by the cylindrical lens is made in this case, and an inspected object is illuminated.

[0012] Here, a wavelength setup by the lighting wavelength setting means is performed as follows. That is, to a line with the predetermined include angle of the above 1st right-angled on the front face of an inspected object, when it is include-angle θ_{1a} and is include-angle θ_{1d} to a line with the predetermined include angle of the above 2nd right-angled on the front face of said inspected object, it is set up so that the wavelength λ of the illumination light may satisfy a degree type (1).

[0013]

[Equation 1]

$$(\sin\theta_i - \sin\theta_d) = N\lambda/p \dots (1)$$

However, n: Degree p of the diffracted light used as the candidate for an image pick-up: Pattern pitch of the front face of an inspected object [0014] Thus, if the wavelength λ of the illumination light is set up, the n-th diffracted light can be efficiently caught with an image pick-up means, and macro inspection using this diffracted light can be conducted efficiently.

[0015] In addition, when catching not the diffracted light but the scattered light with an image pick-up means and conducting macro inspection, a wavelength setup is performed as follows by the lighting wavelength setting means. Namely, are include-angle θ_i to a line right-angled on the front face of an inspected object, and when the 1st predetermined include angle sets to λ wavelength of the illumination light which is include-angle θ_d and is set up by the lighting wavelength setting means to a line with the 2nd predetermined include angle right-angled on the front face of an inspected object include-angle θ_d it is decided by the degree type (3) that will be include-angle θ_d' decided by the degree type (2) -- " -- receiving -- θ_d' -- the wavelength λ of the illumination light which becomes $\theta_d < \theta_d'$ is set up by the lighting wavelength setting means.

[0016]

[Equation 2]

$$(\sin\theta_i - \sin\theta_d') = N\lambda/p \dots (2)$$

$$(\sin\theta_i - \sin\theta_d'') = (n+1)\lambda/p \dots (3)$$

However, n: Degree p of the diffracted light generated from the illumination light: Pattern pitch of the front face of an inspected object [0017] Thus, if the wavelength λ of the illumination light is set up, an image pick-up means will be located between the direction of the n-th diffracted light, and the direction of the following (n+1) diffracted light, and incidence of the diffracted light will not be carried out to an image pick-up means, but only the scattered light will receive. For this reason, macro inspection using the scattered light can be conducted efficiently in this case.

[0018]

[Embodiment of the Invention] Hereafter, the desirable operation gestalt of this invention is explained. The outline configuration concerning the 1st example of the automatic macro test equipment applied to this invention at drawing 1 is shown, and this equipment consists of the illumination-light study system 100 which irradiates the illumination light of the parallel flux of light on the front face of a wafer (inspected object) 3, a light-receiving system 101 which receives the diffracted light from a wafer 3, the scattered light, etc., an image sensor (image pick-up camera) 6, and an image processing system 7.

[0019] The illumination-light study system 100 is constituted by the light source section 1 and the concave mirror 2. The light source section 1 is arranged in the focal location of a concave mirror 2, and the diffused light from the light source section 1 is changed into the parallel flux of light by the concave mirror 2, and is irradiated toward a wafer 3. At this time, a concave mirror 2 has the aperture which can illuminate the whole surface of a wafer 3, and the whole surface of a wafer 3 is illuminated by coincidence by the illumination light of the parallel flux of light. The light source section 1 has the halogen lamp which is a source of the white light, and the interference filter which restricts a lighting wavelength region. The wavelength selection of the light to which two or more interference filters which it functions [interference filters] as a band pass filter which penetrates the light of a predetermined wavelength region, and make the light of a different wavelength region penetrate are changed from the exterior by hand control thru/or remote operation and which is irradiated from the light source section 1 is possible for this interference filter.

[0020] The light-receiving system 101 receives the diffracted light or the scattered light generated from a wafer 3, when a wafer 3 irradiates as mentioned above, and it has the concave mirror 4 with sufficient aperture to incorporate the diffracted light or the scattered light from the whole surface of a wafer 3, and the light-receiving lens 5 to which image formation of the light condensed by carrying out incidence to this concave mirror 4 is carried out. At this time, image formation of the light-receiving lens 5 is carried out to an image sensor 6, and the image of the diffracted light of a wafer 3 or the scattered light is photoed by the image sensor 6.

[0021] Thus, the image of the wafer photoed by the image sensor 6 is sent to an image processing system 7, and macro inspection of surface-discontinuity inspection etc. is conducted here as compared with the image of the normal wafer which is photoed beforehand and memorized.

[0022] In this example, the light source section 1 is arranged near a before [a concave mirror] side focal location, and the wafer 3 is arranged near the backside [a concave mirror 4] focal plane, and, thereby, it makes it the telecentric optical system of the reflective mold using the lieberkuhn. Thus, since the concave mirror is used for optical system, there is no problem of chromatic aberration, and a high inspection of precision is possible.

[0023] The example which conducts macro inspection of a wafer 3 using the automatic macro test equipment of such a configuration is explained. First, a wafer 3 is conveyed in the inspection location shown in drawing 2 according to the conveyance device which is not illustrated. And while corresponding to the above arrangement, corresponding to the class of inspection, the interference filter of the light source section 1 is chosen. In this example, fixed arrangement is carried out, and since the illumination-light study system 100 and the light-receiving system 101 of whenever [incident angle / of the illumination light from the illumination-light study system 100 to a wafer 3] are always fixed and also whenever [angle-of-diffraction / of the diffracted light by which incidence is carried out to the light-receiving system 101] is always fixed, they choose an interference filter so that a desired inspection light may carry out incidence to the light-receiving system 101.

[0024] This point is explained in detail with reference to drawing 3 and drawing 4 . As shown in drawing 3 , when the pattern is repeatedly prepared in the front face of a wafer 3 in the basic pitch p, the relation with thetad becomes [whenever / incident angle / of the illumination light] like a degree type (4) whenever [thetai and angle-of-emergence / of the diffracted light].

[0025]

[Equation 3]

$$(\sin\theta_{tai}-\sin\theta_{tad}) = N\cdot\lambda/p \dots (4)$$

However, λ : Wavelength n of the illumination light: Degree of the diffracted light used as the candidate for an image pick-up [0026] For this reason, when the illumination-light study system 100 is arranged so that parallel flux of light lighting may be performed to a wafer 3 from the direction where whenever [incident angle] becomes include-angle θ_{tai} , the light-receiving system 101 is arranged so that θ_{tad} may be countered whenever [angle-of-reflection / of the diffracted light] and a concave mirror 4 may be located and the wavelength of the illumination light is λ , it turns out that the n-th diffracted light can be most efficiently received by the light-receiving system 101. In this example, fixed arrangement of the illumination-light study system 100 and the light-receiving system 101 is carried out, and an interference filter is chosen so that it may become the wavelength λ on which the n-th diffracted light is most efficiently received by the light-receiving system 101 to the arrangement location.

[0027] On the other hand, the scattered light may be received by the light-receiving system 101, and macro inspection may be conducted. In this case, whenever [n-th angle-of-emergence / of the diffracted light], as shown in drawing 4 , the wavelength λ of the illumination light is set [whenever / angle-of-emergence / of θ_{tad} ' and the following (n+1) diffracted light] up so that the concave mirror 4 of the light-receiving system 101 may be located in the location between θ_{tad} . Specifically, include-angle θ_{tad} of the diffracted light which carries out incidence to the concave mirror 4 of the light-receiving system 101 since θ_{tad} ' is decided by the degree type (5) whenever [n-th angle-of-emergence / of the diffracted light] and θ_{tad} " is decided by the degree type (6) whenever [angle-of-emergence / of the following (n+1) diffracted light] is $\theta_{tad}' < \theta_{tad} < \theta_{tad}''$. The wavelength λ of the illumination light which becomes is set up by the lighting wavelength setting means.

[0028]

[Equation 4]

$$(\sin\theta_{tai}-\sin\theta_{tad}') = N\cdot\lambda/p \dots (5)$$

$$(\sin\theta_{tai}-\sin\theta_{tad}'') = (n+1) \lambda/p \dots (6)$$

[0029] When wavelength λ was chosen as mentioned above and the illumination light of this

wavelength is irradiated by the wafer 3. Since the n -th diffracted light is injected in the direction of include-angle θ , the following $(n+1)$ diffracted light is injected in the direction of θ and the concave mirror 4 of the light-receiving system 101 is located among these, as shown in drawing 4, incidence of the diffracted light is not carried out to the light-receiving system 101, but only the scattered light is received, and macro inspection with the sufficient effectiveness using the scattered light is conducted.

[0030] It returns here, and while being condensed by the light-receiving lens 5 with a concave mirror 4, image formation of the diffracted light or the scattered light received by the light-receiving system 101 as mentioned above is carried out on an image sensor 6 with the light-receiving lens 4. Thus, the image information photoed by the image sensor 6 is sent to an image processing system 6, is contrasted with the image of a normal wafer, and macro inspection is conducted automatically.

[0031] In addition, a rotation support device is prepared in the equipment which supports a wafer 3 in an inspection location, and you may enable it to perform rotation justification of a wafer 3. Like the direction of a pattern of a wafer 3, and a crack defect, when it does in this way, when the generating directions of the illumination light, and the diffracted-light reinforcement and the scattered light differ according to a rotation location, a wafer 3 can be rotated and it can set up in the direction with the most sufficient patient throughput.

[0032] In addition, in the above-mentioned example, although the concave mirror was used, it may change into this and the Fresnel zone plate of a reflective mold may be used. Furthermore, what performed chromatic-aberration amendment by the dioptric system using a lens can also be used.

[0033] Next, the 2nd example of the automatic macro test equipment concerning this invention is explained with reference to drawing 2. In addition, the same sign is attached and explained to the same part as the equipment of the 1st example of the above in the equipment of this example. This equipment consists of the illumination-light study system 102, a light-receiving system 101, an image sensor 6, and an image processing system 7, and only the illumination-light study system 102 only differs from the equipment of the 1st example.

[0034] The illumination-light study system 102 is constituted by the light source section 10, and the optical fiber light transmission system 11 and a cylindrical lens 12, and irradiates the flux of light which can illuminate the whole surface of a wafer 3 at a wafer 3. The light source section 10 consists of a halogen lamp which is white light source light, and an interference filter which restricts a lighting wavelength region. About this, it is the same configuration as the 1st example.

[0035] The light source section 10 is countered, the illumination light from the light source section 10 is received, an other end side (outgoing radiation edge) is arranged in the shape of [of a single dimension] Rhine, and, as for the optical fiber light transmission system 11, the end side (incidence edge) is constituted. For this reason, in a field parallel to the space of drawing 2, the injection flux of light from the other end side of the optical fiber light transmission system 11 is the diffused light with whenever [angle-of-divergence / of an include angle θ], and serves as the light source with the depth for the Rhine length of the fiber to a direction perpendicular to space.

[0036] The other end of this optical fiber light transmission system 11 is located in the location used as a backside [a cylindrical lens 12] focus, and the diffused light injected from the other end side of the optical fiber light transmission system 11 is changed into the flux of light near the parallel flux of light by the cylindrical lens 12 in a field parallel to space. In a field parallel to the space of drawing 2 thereby at least, the parallel flux of light equivalent to the telecentric optical system shown in the 1st example of the above is irradiated all over a wafer 3.

[0037] Thus, if the illumination light is irradiated by the wafer 3, the diffracted light or the scattered light which this produces will be received by the light-receiving system 101, it will be picturized by the image sensor 6, an image processing will be made in an image processing system 7, macro inspection will be conducted, but since it is the same as the 1st example about this, the explanation is omitted.

[0038] the case of such macro test equipment of a configuration -- the configuration of an illumination-light study system -- small -- it can miniaturize and-izing can be carried out [low cost].

[0039] In addition, in the 1st and 2nd examples of the above, it is also possible to constitute the light

source section combining the source of the white light and a spectroscope.

[0040]

[Effect of the Invention] The lighting system by which fixed arrangement was carried out at the 1st predetermined include angle according to this invention as explained above, An image pick-up means for fixed arrangement to be carried out at the 2nd predetermined include angle, and to picturize the image of the inspected object by the diffracted light or the scattered light, Have an image-processing means to conduct macro inspection of an inspected object from the image obtained by this image pick-up means, and further, since it is constituted so that an adjustable setup of the wavelength of the illumination light can be carried out with a lighting wavelength setting means If wavelength is set up so that the direction of the diffracted light injected from an inspected object and the scattered light may be agreed in the light-receiving direction of an image formation photography means, efficient macro inspection can be conducted. For this reason, a lighting system and an image formation photography means are fixable, in the case of this macro test equipment, the movable device in which these sense is changed like conventional equipment is unnecessary, the excessive source of raising dust is lost to it, and contamination of an inspected object can be suppressed to it.

[0041] In addition, it is desirable to constitute a lighting system from an parallel conversion means to change the source of the diffused light and a future light into the almost parallel flux of light, and it is desirable to constitute an parallel conversion means from a concave mirror with which it was arranged in it as the source of the diffused light became a focal location in this case. Thus, also in the case of lighting using the white light, the problem of chromatic-aberration generating is lost by using a concave mirror. Moreover, since it is the same, it is desirable to constitute from a camera means to photo the image of an inspected object from the light which it converged in the image pick-up means with the concave mirror as which the diffracted light or the scattered light from an inspected object is completed, and this concave mirror.

[0042] Moreover, a lighting system can also be constituted from Rhine-like a source of the diffused light, and a cylindrical lens by which opposite arrangement was carried out along Rhine of this source of the Rhine-like diffused light, the flux of light which becomes almost parallel to an one direction at least about the light from the source of the Rhine-like diffused light by the cylindrical lens is made in this case, and an inspected object is illuminated. thus -- if it carries out -- a lighting system -- small -- it can miniaturize and low cost-ization can be attained.

[0043] In addition, when conducting macro inspection using the diffracted light, a wavelength setup by the lighting wavelength setting means is made as [satisfy / the above-mentioned formula (1)]. This formula (1) is conditions to inject the diffracted light in the direction of a light-receiving system (image pick-up means), thereby, can catch the n-th diffracted light efficiently with an image pick-up means, and can conduct macro inspection using this diffracted light efficiently.

[0044] include-angle θ_{d} it is decided by the above-mentioned formula (3) that will be include-angle θ_{d} it is decided by the above-mentioned formula (2) with a lighting wavelength setting means that a wavelength setup will be when catching not the diffracted light but the scattered light with an image pick-up means and conducting macro inspection -- " -- receiving -- θ_{d} -- $<\theta_{\text{d}} < \theta_{\text{d}}$ " The wavelength λ of the illumination light which becomes is set up by the lighting wavelength setting means. Thus, if the wavelength λ of the illumination light is set up, an image pick-up means will be located between the direction of the n-th diffracted light, and the direction of the following (n+1) diffracted light, and incidence of the diffracted light will not be carried out to an image pick-up means, but only the scattered light will receive. For this reason, macro inspection using the scattered light can be conducted efficiently in this case.

[Translation done.]

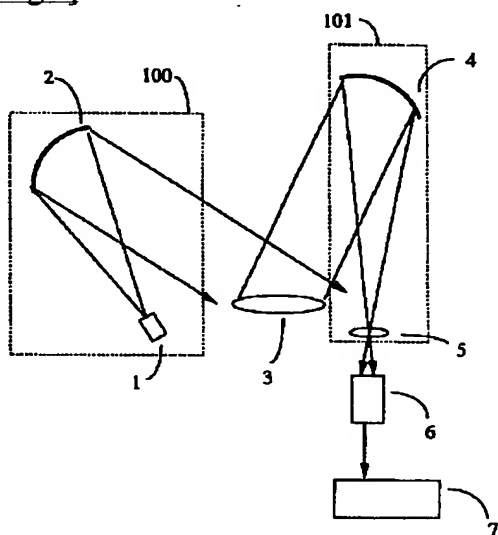
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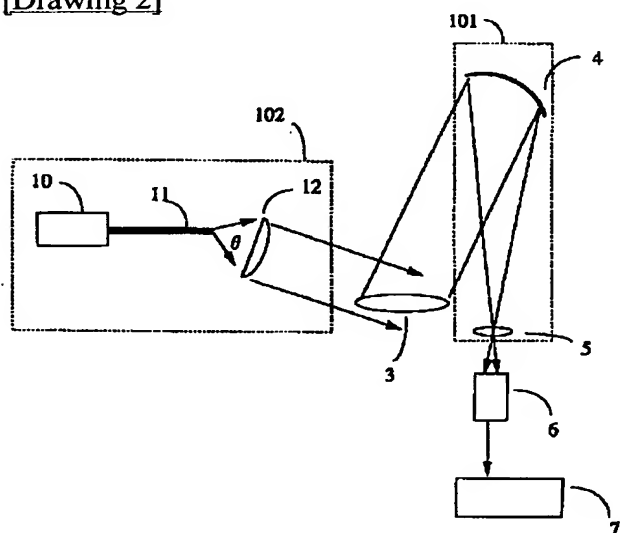
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

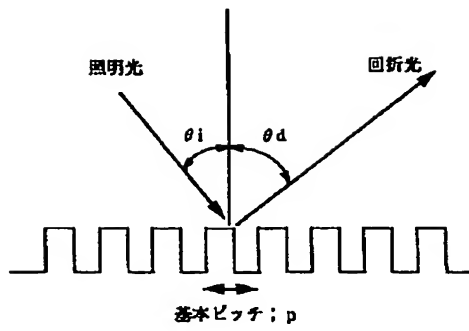
[Drawing 1]



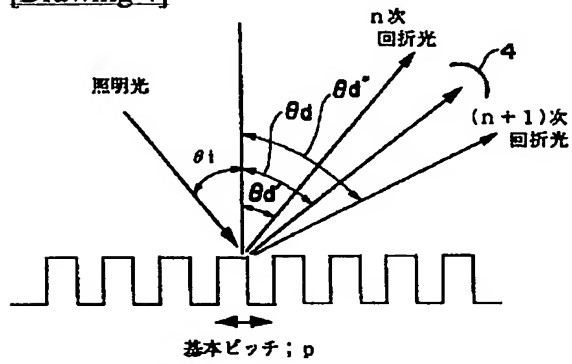
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]